Minimization of NCL in Dense Femtocellular Networks

Savita Kumari, Brahmjit Singh

Abstract: ***Dense femtocells are the ultimate objective of the femtocellular network deployment. Handover in a mobile cellular communication will turn into an increasingly critical issue as cell size reduces. The suitable neighbor cell list is the key component for successful handover in these handover cases. In this paper, we introduce an algorithm for femtocell-to-femtocell handover to make the suitable number of neighbor cell list. In the proposed scheme, the nearby same frequency cells are identified and removed from the Neighbor cell list. The hidden femtocells constituting the nearby femtocells are enhanced in the Neighbor cell list. The simulation results demonstrate that the proposed scheme yields the least number of neighbor cell list.***

Keywords: Femtocell, Macrocell, Handover, Neighbor Cell List.

I. INTRODUCTION

The most of the information movement and voice calls emanate from indoor users. However, due to signal attenuation by walls and different variables, operators fail to provide desirable support to indoor users which encounter issues of poor indoor coverage. This issue raises the requirement for a novel solution i.e. femtocell (FC). A femtocell resolve issues of low-power, and low-cost wireless access point with a short coverage area of indoor users [1]. It interfaces mobile devices to mobile operators utilizing a current broadband internet connection having better indoor coverage and capacity. Femtocell technology offers many advantages to both user and mobile network operator. It provides better indoor coverage, higher data information and higher voice quality to the user and incorporate expanded networks capacity, lessened capital costs and reduced backhaul costs to the network operator [2]–[5]. To fulfill the immense requirement of high wireless capacity, the researchers explored the femtocellular network (FCN) technology. FCN enhance the wireless capacity which is used by different wireless applications. Consequently, the primary target for FCN is the deployment of femtocells at a huge level [6], [7]. The dense scale deployment of FC experiences few difficulties. In the existence of small cells, some aspects are discussed in [8]. The author proposed a model for alleviating interference in the cellular uplink.

The serious concern of a large number of femtocell deployment is a handover. Handover happens when a user moves onto or off a femtocell. Song et al [9] discussed an algorithm for handover decision based on handover energy consumption which decreases the number of unnecessary handovers.. Handover happens either from the femtocell-to-femtocell (FC-to-FC), from the femtocell to the macrocell (FC-to-MC), or from the macrocell to the femtocell (MC-to-FC). Shih-Jung Wu [10] proposed a handover method between FC and MC in hybrid access mode. Chowdhury et al [11] proposed a method for FC-to-FC handover that creates the NCL. The NCL contains received signal strength (RSS), location information, the frequency required by serving Femto Access Point (FAP) and neighbor FAP. The femtocells which are using the similar frequency of the serving FAP are eliminated and hidden femtocells are included in the Neighbor Cell List (NCL) by applying location information coordinated by neighbor FAP. However, the FC-to-MC handover and MC-to-FC handovers confront a few challenges comprising of the suitable neighbor cell list (NCL) and the proper selection of femtocell. A mobility pattern prediction scheme is considered in [12] to lessen the unnecessary handover in macrocell-to-femtocell handover and A Double Threshold Algorithm (DTA) based on Call Access Control (CAC) is presented in [13] to avoid the unnecessary handover between macrocell (MC) and FC.

On the other hand, a novel algorithm is presented in [14] to minimize the neighbor femtocell list and a traffic model is also presented for the integrated MC/FC network. Shahin et al [15] proposed a model to enhance and minimize the NCL by using user movement prediction technique. In this, two parameters are identified to reduce the NCL. First is the movement direction of the mobile station and second is the location of the neighbor FAP relative to the serving Femto access point. Thousands of FCs are deployed in a small coverage area which may cause huge interference effects. Based on the RSS and speed of the user, a handover decision algorithm is described in [16] which selects the most suitable target FC for handover. The NCL can also be optimized using self-configuration phase, a self-optimization phase which is described in [17] that develop the NCL based on measurements presented by mobile stations. In this paper, the focus is on FC-to-FC handover considering a number of FCs in the scenario. We propose a solution towards minimizing the size of NCL.

The rest of this paper is organized as follows:

- Section 2 describes the method to minimize the neighbor femtocell list.
- Section 3 describes

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the handover call flow mechanism.

- Section 4 discussed the simulation results.
- Finally, conclusions are drawn in Section 5.

II. NEIGHBOR FEMTOCELL LIST

For optimum handover decision, to find out the neighbor FAP and determine the exact Femto access point for the handover is a challenging task [6]. The FC-to-FC handover & MC-to-FC handover are of prime concern among all types of handovers because of the difficulties caused by neighbor femtocells. The MS needs to choose the correct target Femto access point among neighbor Femto access points in these handovers. An NCL with a large number of femtocells creates a problem for handover. For scanning many FAPs the mobile station consumes more power. So, more suitable neighbor Femto access point list is necessary for the dense FCN. The interference problem will happen if such a significant number of femtocells are available in a small indoor region. So, there is a problem to find out the exact Femto access point for handover. It is necessary to lessen the size of NCL to minimize the number of scanning. Some unnecessary scanning is done for the handover during large femtocell list. Thus, it is essential to lessen the size of NCL. If some hidden Femto access points are missing in the NCL then it causes handover failure. Thus, the main aim of the proposed technology is to lower the number of FCs by addition of hidden femtocells in the NCL.

Fig. 1 elucidates the outline of dense FCN deployment where serving Femto access point, neighbor Femto access points, and normal Femto access points are present.

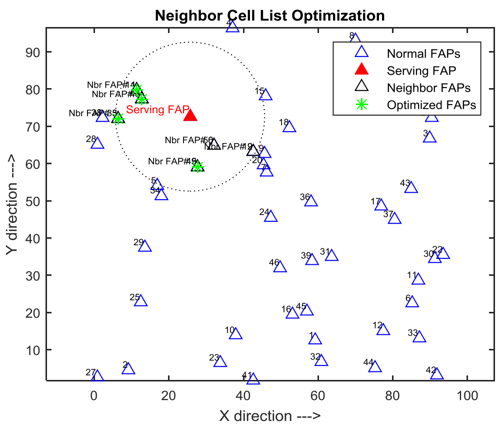

Fig. 1. Scenario of dense femtocellular network deployment

The flow mechanism for optimal NCL is described in Fig. 2. The two threshold levels are considered in which the minimum level of RSS is taken as the first threshold level (S_{T0}) whereas the second threshold level (S_{T1}) is chosen such that S_{T1}>S_{T0}. The S_{T0} is required to detect the presence of a FAP. These levels of received signal strength are utilized to optimize the NCL. By increasing the value of S_{T1}, the number of FCs can be reduced in NCL. If the signal strength from mth FAP is more prominent or equal to S_{T1} then mth FAP is included to the NCL. The FCs which are having a signal strength greater than or equal to the threshold level are considered in category 1 and less than the threshold level are considered in category 2. The non-accessible probability is defined as the probability that a neighbor FAP would be non-accessible from the serving FAP. Then the frequency repetition probability is checked to find out the FCs with the same frequency as that of the serving FAP. The FCs which are using the same frequency and are near to each other are removed from the list. The FAPs which are very close to serving FAP but having signal strength is less than second threshold level are considered as hidden femtocells. Now add the hidden femtocells in the list coordinated by neighbor FAPs and get the optimized NCL. The signal strength of femtocells can find out by using the RSS model.

The received signal strength of femtocells can find out by,

$$RSS = E_t d^{-\beta} 10^{\xi/10} . \qquad (1)$$

where,

d = distance between femtocells

E_t = transmit power of the femtocell

β = path loss exponent

ξ = Gaussian distributed random variable with zero mean and standard deviation up to 12 dB.

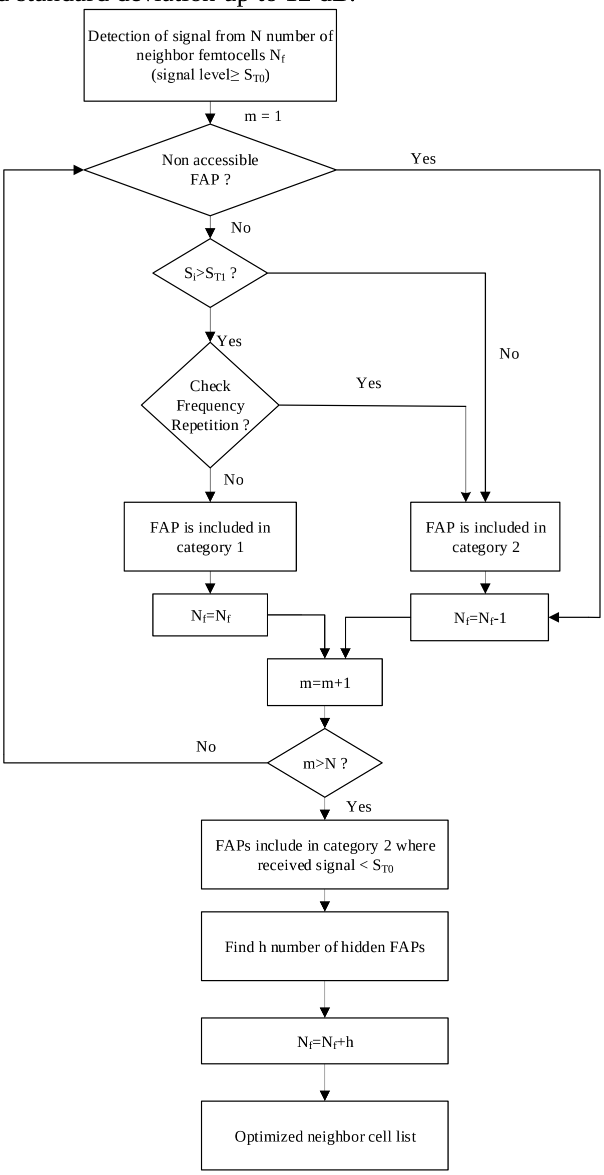

Fig. 2. The flow mechanism for NCL during femtocell-to-femtocell handover

III. HANDOVER CALL FLOW

The capability to consistently switch between the macrocell and femtocell network is the main force behind the FCN deployment. The handover procedures for all types of handover are explained in this section.

A. FEMTOCELL-TO-FEMTOCELL HANDOVER

FC-to-FC handover is a complex task. The number of femtocells is present in a small coverage area. So finding the exact target FAP among neighbor FAPs is a challenging task. Fig. 3 shows the procedure for the FC-to-FC handover. If the signal strength of serving FAP goes down then it needs to connect to other FAP which is having higher signal strength. The mobile station searches the FAP from neighbor FAPs which is having higher signal strength. The mobile station, serving FAP, and neighbor FAP performs the self-organizing network configuration to achieve the optimized NCL for handover. Based on the strength of the signal and pre-authentication, the mobile station and serving FAP decide for handover to target FAP. The request for handover is sent by the serving FAP via Femto gateway (FGW) to target FAP. Then target FAP checks the user authentication. When serving FAP received the handover response from target FAP, a link is generated to transfer the packet data to target FAP. Then, the mobile station renews a channel with target FAP. Now a handover complete message is sent to FGW by the mobile station to indicate that the mobile station effectively finished handover and synchronized with target FAP.

B. FEMTOCELL TO MACROCELL HANDOVER

Fig. 4 explain the handover procedure for FC-to-MC handover. If the signal strength is getting low, the mobile station delivers the report to the concerned FAP and find the new signals from the MBS and neighbor FAPs. Then the NCL list is optimized. The mobile station executes the pre-authentication of all the access networks which are comprised in NCL. Based on signals levels, the mobile station and serving FAP decide for handover to the MBS. Then the handover procedure starts by sending a handover request to the MBS. The radio resource control (RRC) and call admission control (CAC) are implemented to check that the calls are accepted or not. The macrocellular base station responses for handover request and a new link is set up. The mobile station renews a channel with target FAP. Now a handover complete message is sent to FGW by the mobile station to indicate that the mobile station effectively finished handover and connected with target MBS.

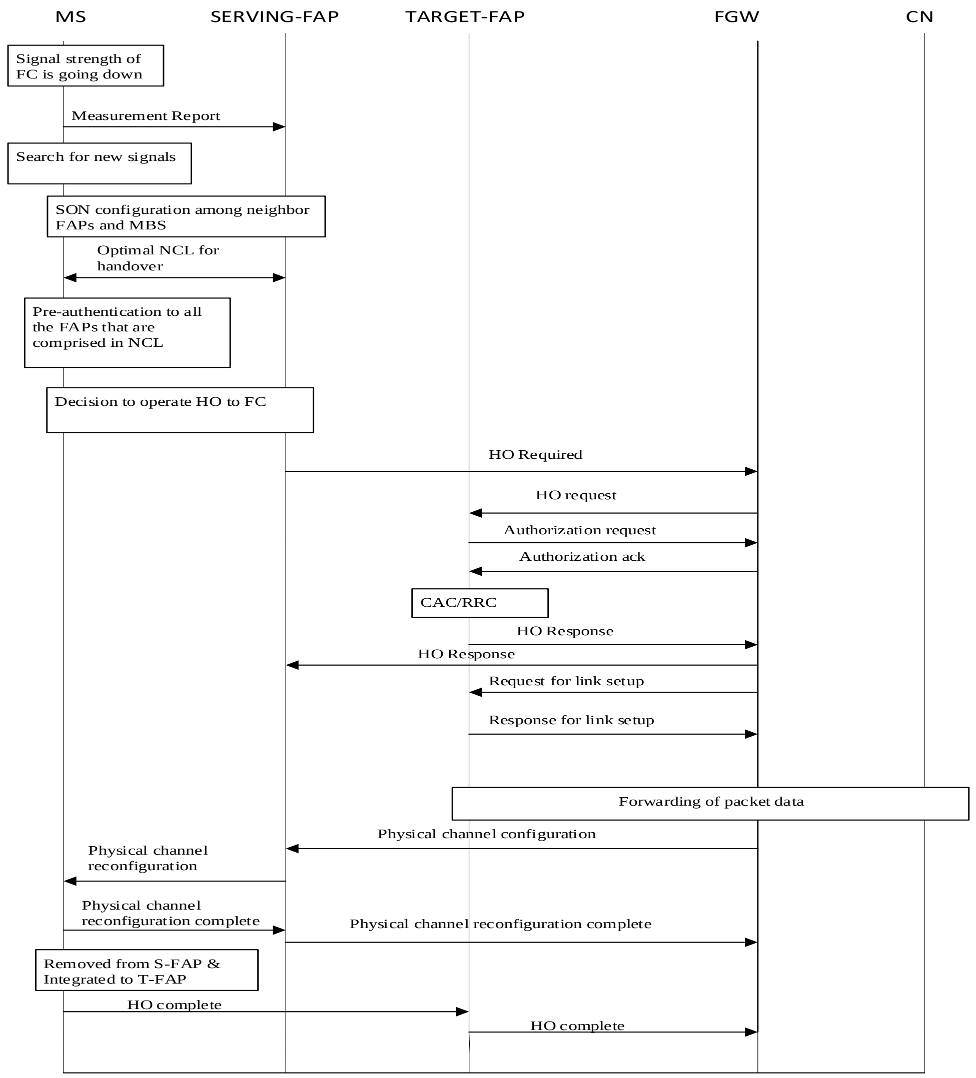

Fig. 3. FC to FC handover for dense FCN deployment

C. MACROCELL TO FEMTOCELL HANDOVER

Fig. 5 explain the handover procedure for MC-to-FC Handover. The mobile station chooses the suitable FAP among numerous FAPs. When a mobile station received any signal from FAP then it delivers the report to MBS. The enhanced NCL for handover is optimized. The mobile station executes the pre-authentication of all the access networks which are comprised in NCL. Based on signals levels, the mobile station selects for handover to target FAP. Then the handover procedure starts b sending the handover request. The radio resource control (RRC) and call admission control (CAC) are implemented to check that the calls are accepted or not and interference levels also compare. Thus the target FAP reply for the HO request to the MBS and a new channel is set up. The data are further transferred to the target FAP and mobile station creates a new channel with the target FAP. Now a HO complete message is sent to FGW by the mobile station to indicate that the mobile station effectively finished handover and connected with target FAP.

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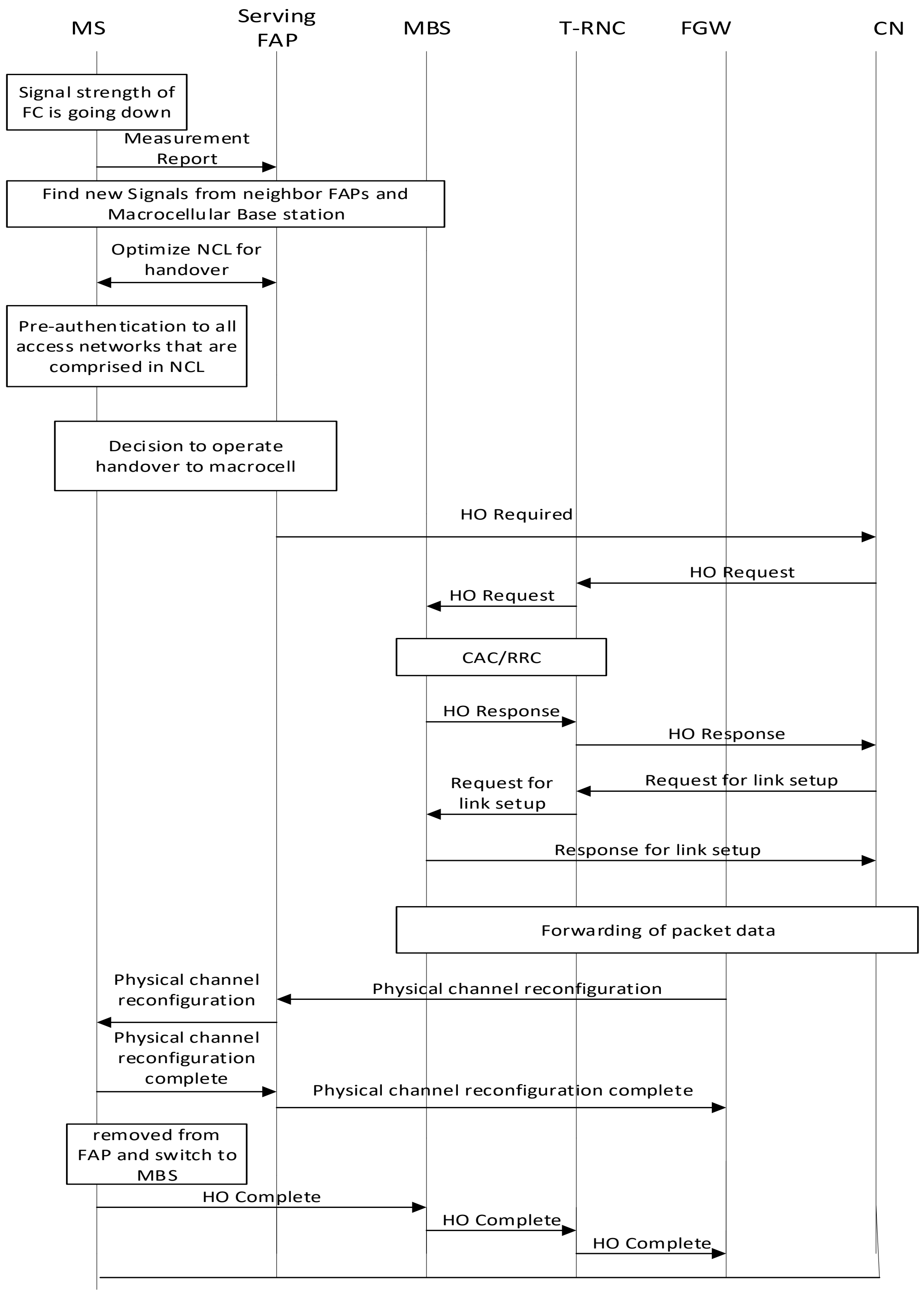

Fig. 4. FC to MC Handover for a dense FCN deployment

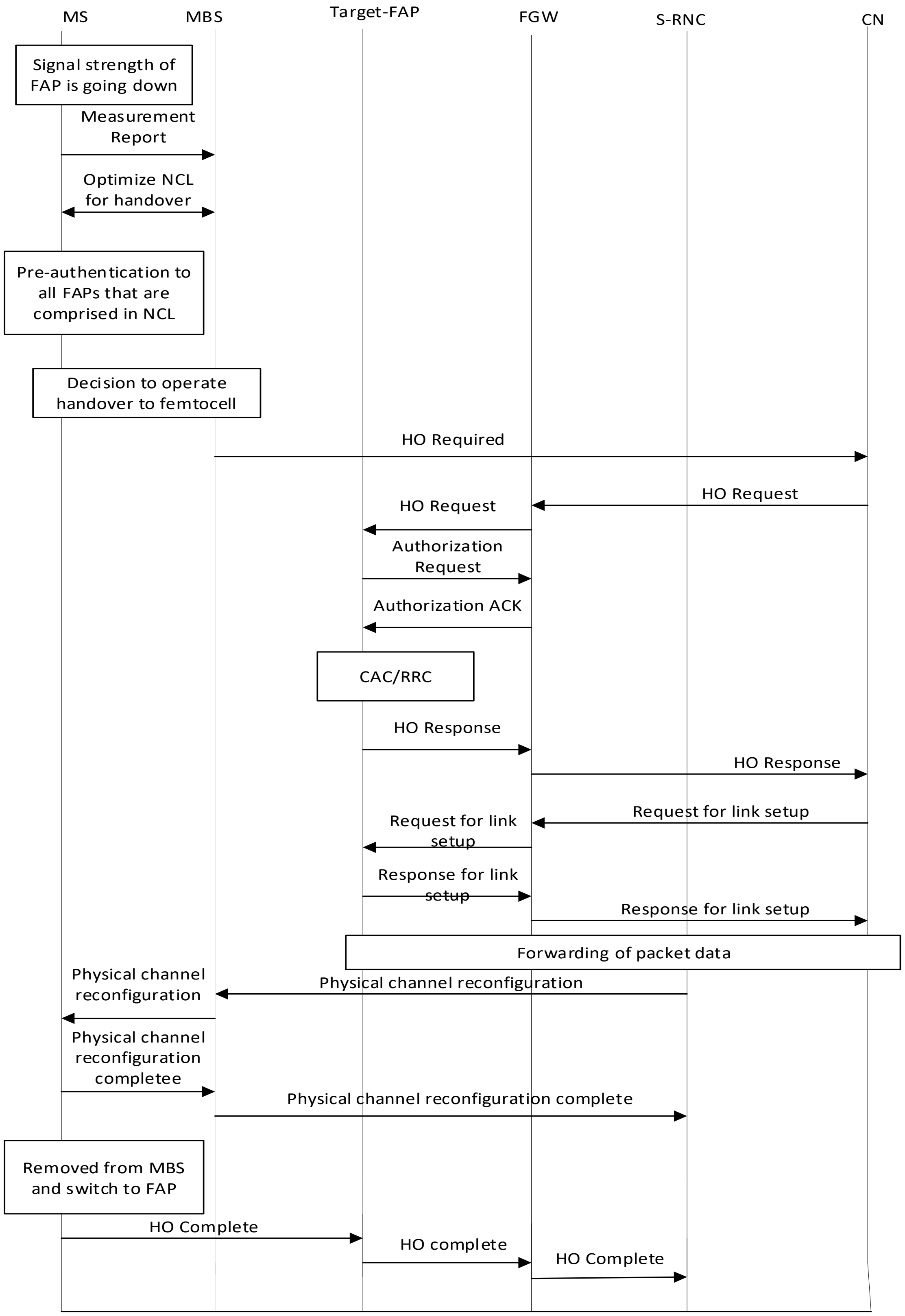

Fig. 5. MC to FC Handover for dense FCN deployment

IV. SIMULATION RESULT

The performance of improved NCL using

simulation result is verified. The simulation parameters are shown in table 1. The number of femtocells is generated randomly. Based on the strength of signal of neighbor FAPs, the femtocells are included in the list. The performance of traditional scheme [6] is compared with our proposed scheme. The traditional scheme includes a FAP in NCL if the received signal level from that FAP is greater than or equal to S_{T0}. The traditional NCL is based on RSS only and cannot cover the hidden FCs. Thus, there is a possibility that the NCL doesn't contain hidden FCs. This will result in failure of a handover to the target FC. By increasing the number of deployed FCs in a given area increases the probability that the neighbor FCs coordinate with the serving FC. Thus, there is a reduction of probability that the hidden FCs are out of NCL by increasing the number of deployed FCs. This will result in a decrease in the handover failure rate.

Table 1. Simulation parameters

Parameter	**Value**
Radius of femtocell	30 m
Transmit power of the femtocell	10 mW
First threshold value of received signal (S_{T0})	-90 dBm
Carrier frequency of femtocell	1.8 GHz
Second threshold value of received signal (S_{T1})	-75 dBm

Fig. 6 describes the missing probability of the target FC from the NCL. The hidden FCs are not included in the traditional NCL due to which the probability of the target FC is excluded from the NCL which results in the failure of a handover. The probability that a neighbor FC organizes with the serving FC can be increased by increasing the number of FCs and keep updated about the location of the hidden FC. Therefore, the possibility of the hidden FC which is out of the list is reduced with the increase in a number of FC. Also missing the suitable FC from the NCL causes a handover failure. This results in a decrease of handover rate with the increase of a number of FC.

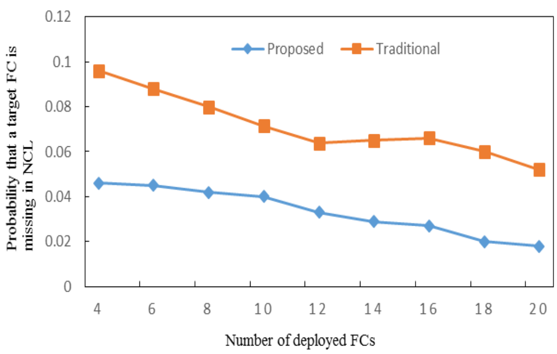

Fig. 6. The probability that the target FC is missing from the NCL

Fig. 7 describes the number of neighbor FC in the NCL. The result indicates that the NCL having a minimal number of FC during FC-to-FC handover. As the number of deployed FCs in a given area increases, the number of FCs in NCL increases in the traditional scheme and less in the proposed scheme.

The result describes that the neighbor FC list for the FC-to-FC handover has an optimal number of FCs. The handover failure probability will not increase due to the reduced number of FCs in the neighbor FC list.

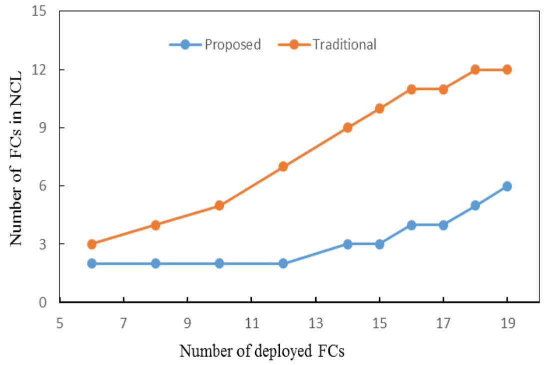

Fig. 7. Comparison of the number of neighbor FCs in the NCL

V. CONCLUSIONS

Optimizing the handover performance in the emerging Femto cellular networks is of prime concern and an important technical challenge. In this paper, we have proposed a scheme to minimize the size of the neighbor cell list and handover rate. In the proposed scheme, the nearby same frequency cells are identified and removed from the NCL. Hidden femtocells constituting the nearby femtocells are enhanced in the NCL. Numerical results show that the proposed scheme reduces the size of NCL which in turn requires fewer number of scanning process. This, in turn, results in enhanced handover performance in Femto cellular networks.

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